An acoustic study of sound change in progress

Senior Thesis

Presented in Partial Fulfillment of the Requirements for Graduation "with Research Distinction in Speech and Hearing Science" in the Speech and Hearing Science Department of The Ohio State University

by:

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I would like to thank Dr. Fox and Dr. Jacewicz, co-directors of the Speech Perception and Acoustics Laboratory, for their help and guidance throughout this project.

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Abstract

There are many different regional dialects of American English most of which differ as a function of vowel quality—historically, these vowel differences are a product of sound change over time. The current project focuses on the North and Midland dialects of English for the purpose of identifying ongoing changes in vowel pronunciation. The most prominent mechanism of vowel shift in the Northern dialect is called the Northern Cities Shift (NCS). The Midland dialect has long been considered to not be participating in the NCS, but the data are somewhat dated. The question addressed in this study is whether the NCS is still operative in the Northern dialect and/or is now operative in the Midland dialect. We will compare recordings of speakers (from three different age groups) from southeastern Wisconsin (representing the Northern dialect) and from Central Ohio (representing the Midland dialect) in terms the acoustic properties of a set of six vowels known to participate in the vowel shift (with special focus on two vowel classes called the LOT and the STRUT vowels). Speakers produced 13 different sentences containing these vowels in a stressed position. The speech analysis programs Adobe Audition and TF32 were used to analyze each token. The acoustic properties of these vowels included vowel and word duration and the first three formant frequencies measured at five points in each vowel (to allow examination of spectral change). Statistical analysis of these data is now close to completion. However, preliminary results suggest that some aspects of the NCS are not found in Wisconsin speakers (e.g., the fronting of the LOT vowel). The expected pattern is found in the Ohio Speakers.

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1. Introduction

Studies in dialectology and sociolinguistics have shown that there are several dialects within North American English defined by six major geographic regions: North, West, South, Midland, New England, and Mid-Atlantic (Clopper et al., 2005; Labov et al., 2006). These regions have been defined on the basis of linguistic fieldwork in which large samples of speech have been collected over decades and analyzed for the occurrence of linguistic markers related to vowel production. The major scholarly work in this area is the Atlas of North American English (Labov et al., 2006). In the Atlas, the regional boundaries are determined by drawing the isoglosses corresponding to specific linguistic features found in the pronunciation patterns of the speakers in a given geographic area. For example, the outer limit of the North is defined by the lack of the low back vowel merger (i.e., the vowels in *cod* and *caught* are phonologically distinct and do not merge in production and perception as in the Midland) and by the lack of fronting of the back vowel /o/ (e.g. *home*), which is produced farther back in the vocal tract. These six major dialect regions, adapted from Labov et al. (2006), are depicted in the map in Figure 1 below. The North (in red) and the Midland (in green) are of immediate relevance to the present thesis and will be discussed in greater length in subsequent sections.

The nature of sound change can be illustrated by an earlier event known as the Great Vowel Shift (Pyles, 1964, p. 173). This phenomenon, affecting a number of Germanic languages during the fourteenth century, was particularly significant in the development of Modern English not only for the change in pronunciation of words, but also their spelling. For example, the word *bead* as it is pronounced today with the vowel /i/, was formerly pronounced with /e/ (Pyles, p. 174).

This study will focus on the production of selected vowels which are currently undergoing a change in pronunciation in the North and Midland dialects. Such vowel changes are common in languages with rich vowel systems such as English. These vowel changes (or sound changes) are another defining mark of dialect regions in North America. The specific rotations of the vowels in the vowel space over time, a product of a change in pronunciation, have been termed vowel shifts and mergers. The most prominent vowel shifts in American English are the Northern Cities Shift, the Southern Shift and the Canadian Shift, but there are also a number of smaller changes and vowel rotations within each dialect region. These major sound changes are briefly characterized in section 1.1.

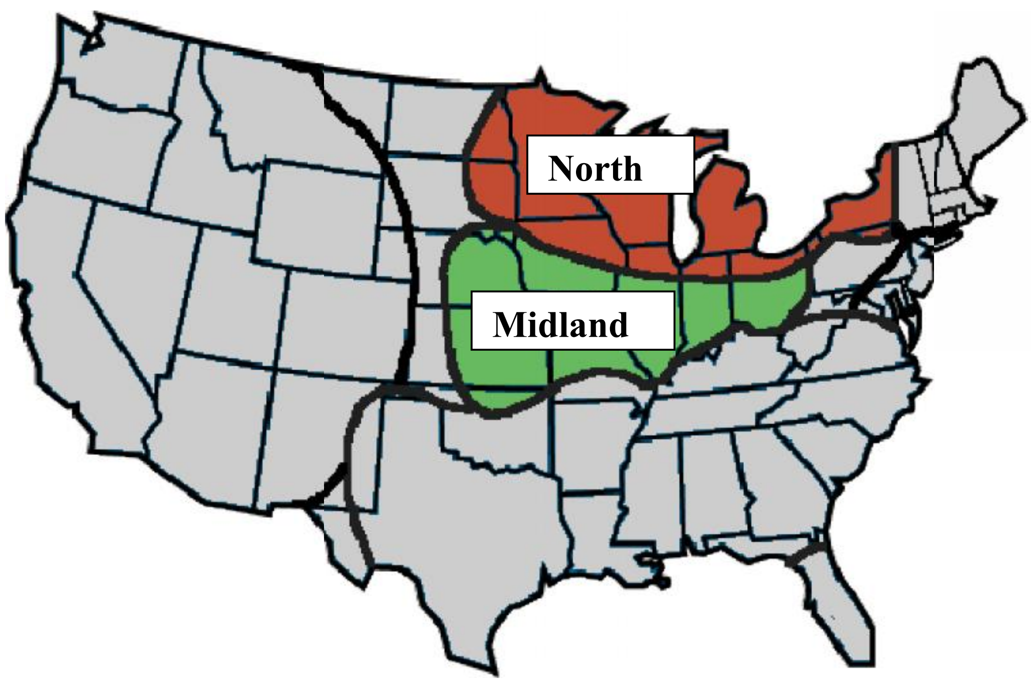

Figure 1. A map outlining the six boundaries North American English dialects from Phillips & Clopper (2011).

1.1. Sound change in the vowel systems of American English

This section presents a short description of three major sound changes in the vowel systems in American English spoken both in the United States and in Canada: The Northern Cities Shift, the Southern Shift and the Canadian Shift (Boberg, 2005; Clarke et al., 1995; Labov et al., 2006; Thomas, 2001).

A. <u>The Northern Cities Shift</u>

The Northern Cities Shift (NCS), found in big cities such as Detroit, Toledo, Buffalo, and Chicago, is defined in the Atlas (Labov et al., 2006) as a systematic rotation of six vowels. The initial movement which triggers the shift is the raising and fronting of /æ/, as in the word *bats* (Stage 1). Since this movement leaves an open area in the low region of the vowel space where the /æ/ originally was located, the next change that occurs is the fronting of /ɑ/, as in the word *cot* (Stage 2). The next change involves the lowering and fronting of /ɔ/, as in the word *thought* (Stage 3). Next, the lowering and backing of /ɛ/ occurs, as in the word *dress* (Stage 4). The backing of /ʌ/, as in the word *cuts,* occurs next, moving towards the space formerly occupied by /ɔ/ (Stage 5). The final stage is the lowering and backing of /ɪ/, as in the word *bits*, where /ɛ/ used to be positioned. A schematic of this shift is shown in Figure 2.

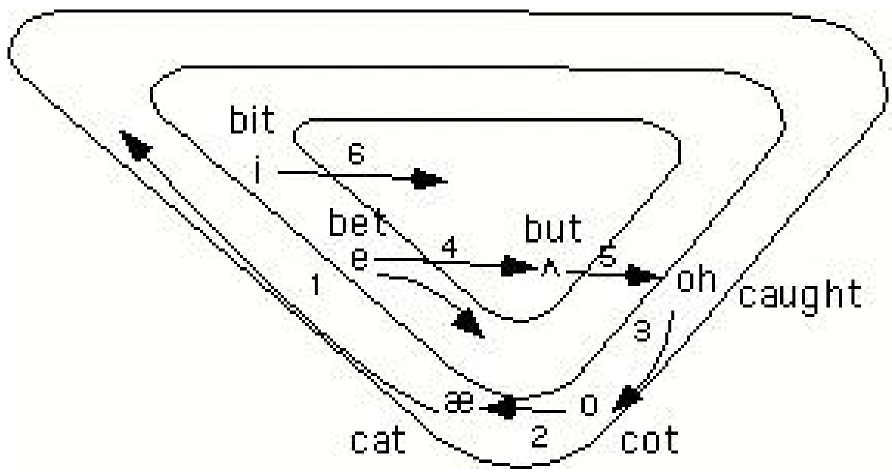

Figure 2. A schematic of the Northern Cities Shift from Labov (2002).

B. The Southern Shift

As outlined in the Atlas (Labov et al., 2006), the Southern Shift, which is found in 16 southern states, e.g. Alabama, Louisiana, Tennessee, North and South Carolina, Virginia, Texas, is initiated by a glide deletion in the diphthong /ɑi/, such as in the word *guy* (Stage 1). This initial stage then triggers the reversal in position of /e/, as in the word *bait*, and /ɛ/, as in the word *bets* (Stage 2), making /e/ lower and more towards the back, so that /ɛ/ can now become higher and more towards the front, close to the original position of /e/. The final change which occurs is the reversal of /ɪ/, as in the word *bits,* and /i/, as in the word *beats* (Stage 3). A schematic of this shift is shown in Figure 3.

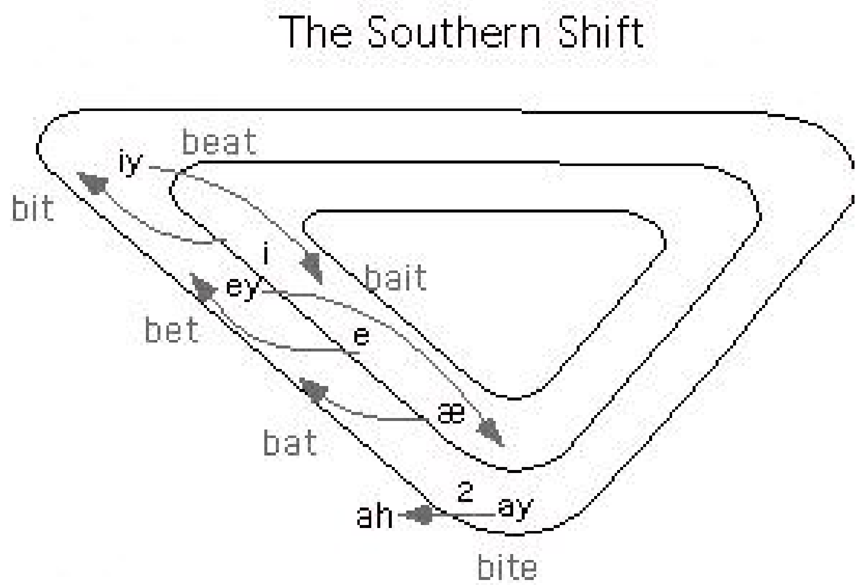

Figure 3. A schematic of the Southern Shift from Labov (2002).

C. The Canadian Shift

As Clarke et al. (1995) noted, the Canadian Shift is found in parts of Canada, with higher concentration in Montreal and Ontario. The shift involves the lowering of front mid and high lax vowels. First, the vowel /ɑ/, as in *pots*, goes further to the back of the vowel space to merge with /ɔ/, as in the word *caught* (Stage 1). This then allows /æ/, as in the word *cat*, to move lower into the original space which was formerly occupied by /ɑ/ (Stage 2). Next, the vowel /ɛ/ as in the word *bets,* moves lower and further back into the space which /æ/ used to occupy (Stage 3). Finally, the vowel /ɪ/ moves into the space which was originally occupied by /ɛ/ (Stage 4). A schematic of this shift is shown in Figure 4.

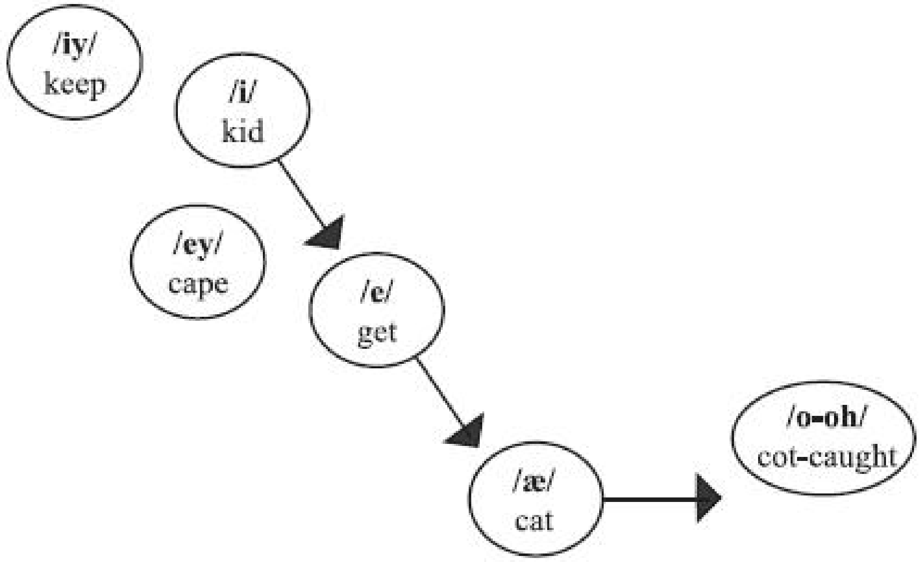

Figure 4. A schematic of the Canadian Shift from Ward (2003).

1.2 Vowel changes in the Midland and in the North

As Labov et al. (2006) states, the Midland region's main distinction from other surrounding territories is the occurrence of a low-back merger. Specifically, /ɑ/ has a tendency to merge with /ɔ/. For example, the vowel in word *cot* will have the same acoustic quality as the vowel in the word *caught* so that the phonological contrast between the two is neutralized. The region is characterized by several features: first, the vowel /o/ tends to be fronted in the Midland, and seems to be especially so in central Ohio. The diphtong /aʊ/ also has a tendency to be fronted. The Midland region is additionally characterized by its tendency to make glide deletions before a resonant, as in the word *tire*, which goes from /tajɹ / to /taɹ /. The third distinction of the Midland region is its fronting of /ʌ/, which seems to be more prevalent in younger speakers.

Jacewicz, Fox, and Salmons (2011) confirmed the existence of dialect differences within North American English, and specifically focused on the differences between the South, Midland, and Northern regions. While they found significant differences between the Northern and Southern dialects, the results of the Midland vowel productions in comparison to the other two brought up the question of whether the Midland could be considered a region with its own distinct dialect, or if it was an area of transition between North and South. Much of the results showed similarities between the North and Midland, and also similarities between the South and the Midland. Labov et al. (2006) found two defining characteristics for Central Ohio: first, that /æ/ had a tendency to be raised, and that there was also a low back merger.

In contrast with the Midland and Central Ohio, Labov et al. (2006) found that the Inland North was an area of concentration of NCS features with a strong tendency to resist the low back merger. As for southeastern Wisconsin, the region in the Inland North where their cross-generational study was conducted, Jacewicz et al. (2011) found only weak evidence for the participation of this region in the NCS. While Labov et al. (2006) had reported the area to be using the shift fully, Jacewicz et al. (2011) did not find the shift to be operative in the younger generation of speakers. Purnell (2010) stated that while some aspects of the shift, such as the raising of /æ/ and lowering of /ɛ/were evident in his data, the area did not show stages of the NCS with regards to the other vowels.

1.3 The relation between the vowel classes STRUT and LOT

Labov (2010) refers to a relationship between the North and the Midland and their production of the STRUT (/ʌ/ as in *cuts*) and LOT (/ɑ/ as in *pots*) vowel classes. This relation characterizes the dialect boundary between the North and Midland regions. Labov concluded that the speakers in the areas participating in the NCS produce the /ʌ/ vowel further back in the vocal tract than the /ɑ/ vowel. However, this relation is reversed by speakers in the Midland whose /ʌ/ is much more fronted than the /ɑ/. This difference in the production of the two vowels in the North and the Midland is a function of two distinct pressures on their respective vowel systems. While the operation of the NCS in the North causes the positional change (fronting) of /ɑ/ (Stage 2) and backing of /ʌ/ (Stage 5), the change affecting both vowels in the Midland is of a different nature. In particular, because the vowel /ɑ/ is merging with /ɔ/ in the Midland, the movement toward the low back vowel merger causes backing of /ɑ/ and no change to the position of /ʌ/. As a result, the /ʌ/ in the Midland is fronted and /ɑ/ is produced in the back of the vocal tract whereas the /ʌ/ in the North is in the back and /ɑ/ is fronted. Labov (2010) points out that this is a relatively recent sound change. The oldest speakers in the North and in the Midland who were used as participants in the Atlas (Labov et al., 2006) tended not to show these differences, which became later evident in younger speakers. This implies that within the North and the Midland, children have a tendency to deviate from the system used by their parents despite their extended time in their respective regions.

1.4 Aims of the present study

The relatively small sample of speakers used in the Atlas (Labov et al., 2006) poses a problem of reliability. In particular, since the NCS has not been fully operative in southeastern Wisconsin (Jacewicz et al., 2011; Purnell, 2010), it remains to be shown if the relation between the STRUT and LOT vowels is as reported for the North. Furthermore, the Central Ohio region is not very well represented and more recent published data are unavailable. For these reasons, the current study uses a larger sample size to examine possible cross-generational changes.

Labov's report will be either confirmed or rejected, based on data from both regions. We will seek to find evidence of regional differences and patterns compared to his findings. The study will also show if children do in fact deviate from the older generations' patterns, as Labov proposed. Also, we seek to confirm previous findings that women might be the leaders in sound change.

2. Methodology

2.1 Participants

Recordings from the 109 participants used in this study originated from a larger set of recordings obtained in an earlier study on dialect variation done in the Speech Perception and Acoustics Laboratory. The speakers were selected based on their residency in central Ohio and southeastern Wisconsin, representing speakers of the Midland and Inland North dialects, respectively. 55 participants were from central Ohio and 54 were from southeastern Wisconsin. In each region, participants represented both genders (males and females) and three generations: children (ages 8-12), parents (35-51), and grandparents (66-91). In that as well as in the present study, the use of the terms "parents" and "grandparents" in indicative of adults of middle and older age, respectively, and does not indicate a necessarily biological relationship.

The children's targeted age was 8-12 years old, and the mean age of the children selected for the present study was 10.2 years old. The targeted age of "parents" (the middle aged adults) was 35-51 (mean: 42.2 years old) and of "grandparents" (the old adults) was 66-91 years old (mean: 74.6 years old). The distribution of the participant into age and gender groups is listed in Table 1.

Table 1. Total number of participants within each age and gender subgroup, with their calculated mean ages (in years) and standard deviations. Abbreviations: C=children, P=Parents, GP=Grandparents, M=male, F=female.

Participant group	Gender	Number of participants	Mean age (stdev)
OH_C	M	10	11.3 (1.9)
	F	10	10.3 (1.6)
OH_P	M	9	41.6 (5.5)
	F	11	41.2 (3.8)
OH_GP	M	8	70.5 (2.3)
	F	7	73.6 (3.3)
WI_C	M	10	9.4 (0.8)
	F	10	9.8 (1.4)
WI_P	M	8	43.5 (4.2)
	F	10	42.4 (4.5)
WI_GP	M	8	74.8 (5.6)
	F	8	79.4 (7.0)

The participants in central Ohio most often came from Columbus, Worthington, while those in southeastern Wisconsin came most often from Madison, Middleton, and Sun Prairie. A diverse range of occupations and education levels were represented in both regional groups. More details about the age, occupation, education level, and geographic location of each participant can be found in Appendix A.

2.2 Stimulus material

The stimulus material for this study consisted of read sentences. These recordings were done earlier, and for the present study only 7 sentences were chosen from each participant's set of 240. Each sentence had one of the following target words: *bits, thought, pots, bets, bats, cats,* and *cuts* corresponding to the vowels /ɪ, ɔ, ɑ, ɛ, æ, ʌ/, respectively. For the vowel /æ/, two words (*bats* and *cats*) were selected to examine the effects of consonantal context and possible acoustic differences due to lexical effects. Although the main interest in this study was in the vowels in *pots* and *cuts*, the remaining 4 vowels participating in the Northern Cities Shift were additionally analyzed in order to detect cross-generational changes in their productions. The discovery of such changes could provide evidence that sound change is an active process in each dialect region. Each sentence was produced twice with the exception of the sentence containing *thought*, to create a total of 13 sentences for each subject. 1417 total tokens were used for data analysis (109 x 13).

In each sentence, the main sentence stress was placed on the target word (in bold), which created a uniform set of stressed vowel tokens for acoustic analysis.

1) /ɪ/: John knows the small **bits** are sharp.

5) /ɔ/: John **thought** the small bets are low.

4) /ɑ/: John said the small **pots** are low.

2) /ɛ/: John said the small **bets** are low.

3a) /æ/: Doc said the small **bats** are fast.

3b) /æ/: Jane thinks the small **cats** are cute.

6) /ʌ/: Sue thinks the small **cuts** are deep.

2.3 Acoustic measurements and statistical analyses

A waveform analysis program, Adobe Audition, was used to locate the acoustic landmarks in each sentence. The acoustic landmarks for subsequent analysis were word onset, word offset, vowel onset, and vowel offset. The vowel in each acoustic waveform was identified by the presence of periodicity due to glottal pulsing following the word-initial consonant. The vowel onset was located at the first positive peak of this periodic waveform (following either a stop closure release or cessation of frication noise), and was located at a zero-crossing. The vowel offset was located at the first point in which periodicity of the vowel ended, signaling the stop closure. These landmark locations were entered by hand in spreadsheet and served as input to a custom program written in Matlab which computed vowel duration values. This Matlab program was also used to check all segmentation decisions which were displayed as vertical marks superimposed over a display of the waveform, as shown in Figure 5.

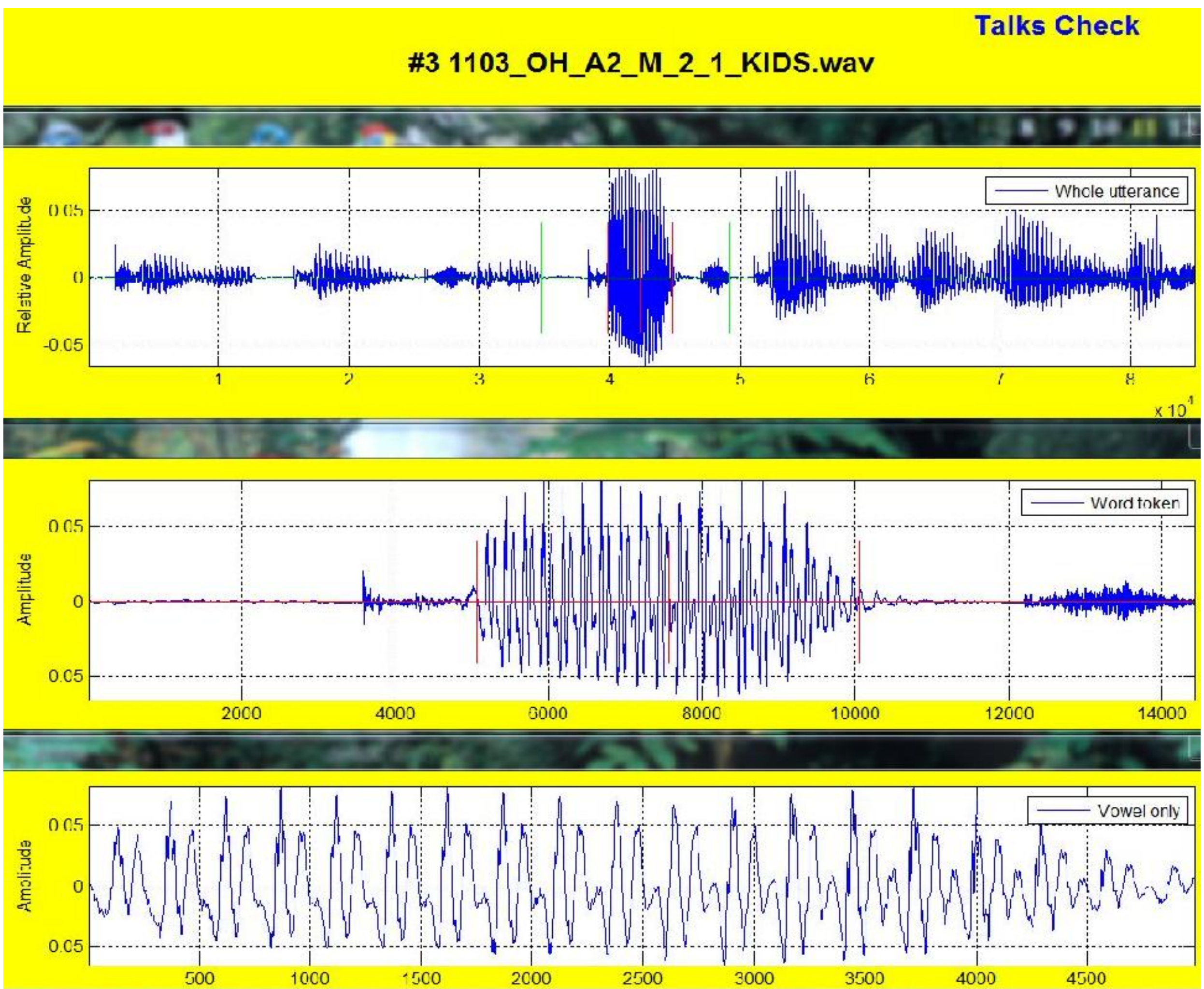

Figure 5. Custom Matlab program used as check for acoustic landmark points.

The same acoustic landmarks served as input to the subsequent analysis of the frequencies of the first two formants (F1 and F2). A separate Matlab program was written to analyze the frequencies of F1 and F2 at five equidistant temporal locations corresponding to the 20–35–50–65–80%-points in the vowel to allow an estimation of formant movement. The frequencies of F1 and F2 were measured by centering a 25-ms Hanning window at each temporal location. F1 and F2 values were based on 14-pole LPC analysis and were extracted automatically. A screenshot of this program is shown in Figure 6.

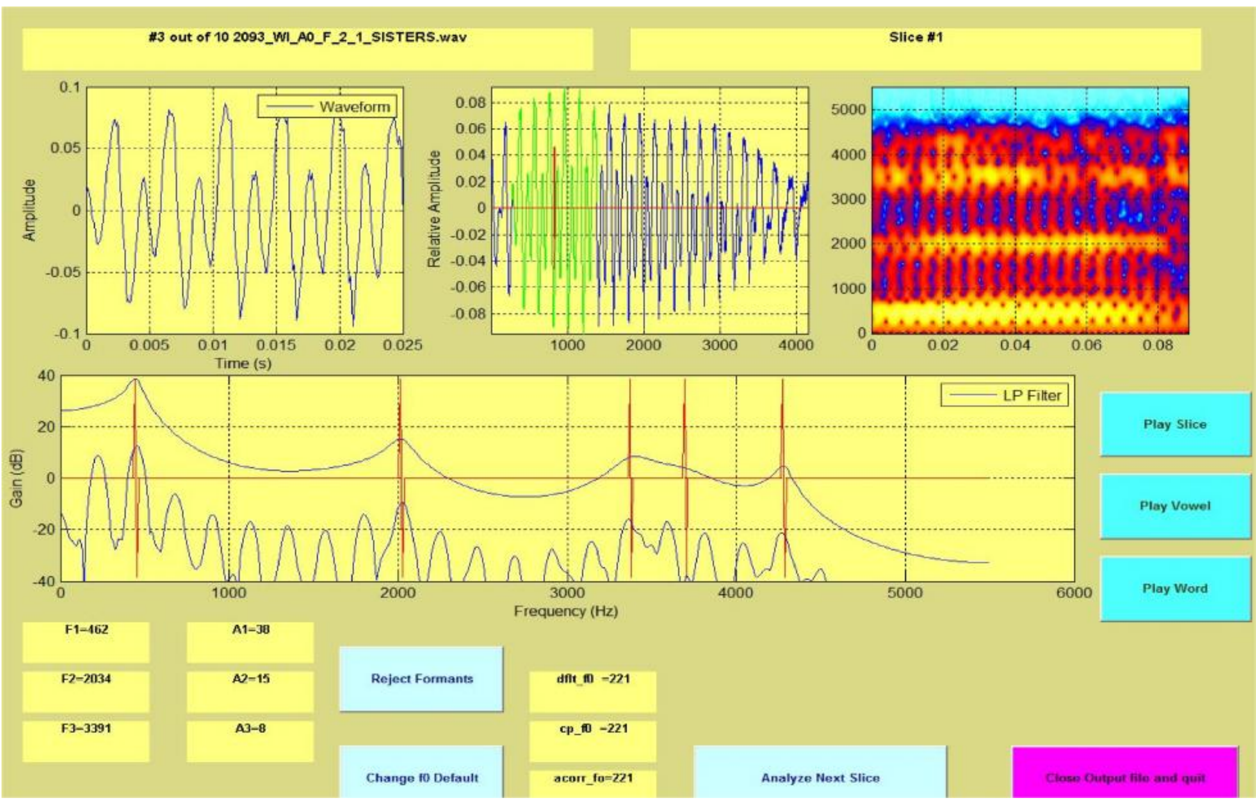

Figure 6. A screen shot of the program used for formant measurement.

The entire set of formant measurements were later re-checked using a separate Matlab program which displayed formant frequency marks and, as needed, verified using smoothed FFT spectra and formant tracks displayed in wideband spectrograms (using the program TF32, Milenkovic, 2003). A screenshot of this program is shown in Figure 7. Any errors in formant estimation in LPC analysis were hand corrected.

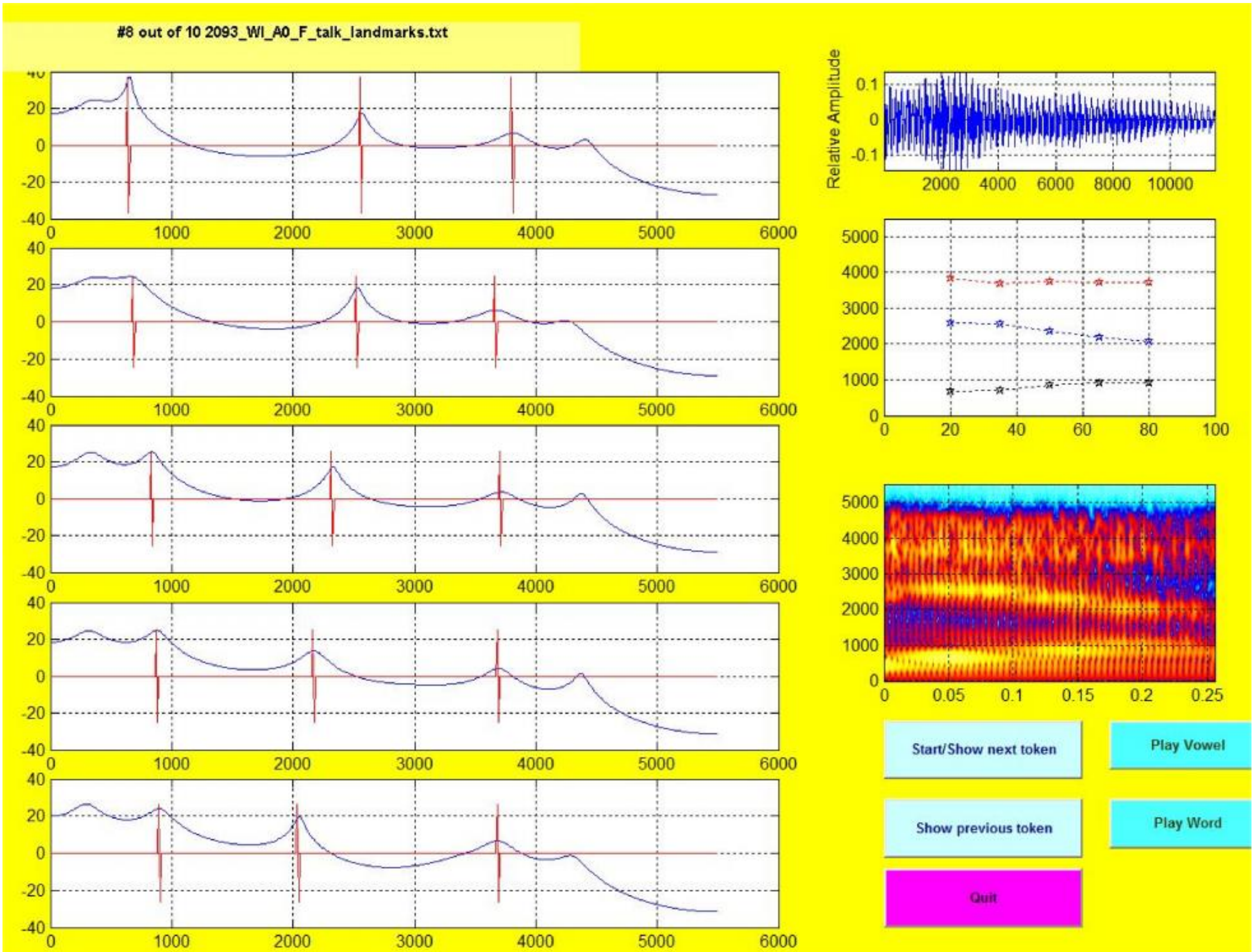

Figure 7. A screen shot of the program used to check formant measurements.

3. Results

3.1 Vowel Duration

When comparing vowel durations in each dialect, the overall mean was slightly shorter in Ohio than Wisconsin (OH=151.91 ms, WI=155.40 ms). We found that in both regions /ʌ/ had the shortest duration (OH=115.36 ms, WI=104.38 ms), while /ɔ/ had the longest (OH=206.84 ms, WI=215.39 ms). The vowels /ɪ, ɛ, ʌ/ had longer durations in Ohio, while /æ, ɔ, ɑ/ had longer durations in Wisconsin. In terms of speaker age, the mean vowel duration was longest in the parent group (P=156.21 ms), followed by children (C=153.81 ms), and then grandparents (GP=150.64 ms). The females in both regions had longer mean durations for all six vowels (154.99 ms), than males (152.21 ms). For the vowel /æ/ each subject produced two words, *bats* and *cats*. When comparing vowel durations for these two vowels, *bats* had a longer duration (199.29 ms), while *cats* had a shorter duration (170.41 ms), due to its longer voice onset time. These results are shown in Figure 8.

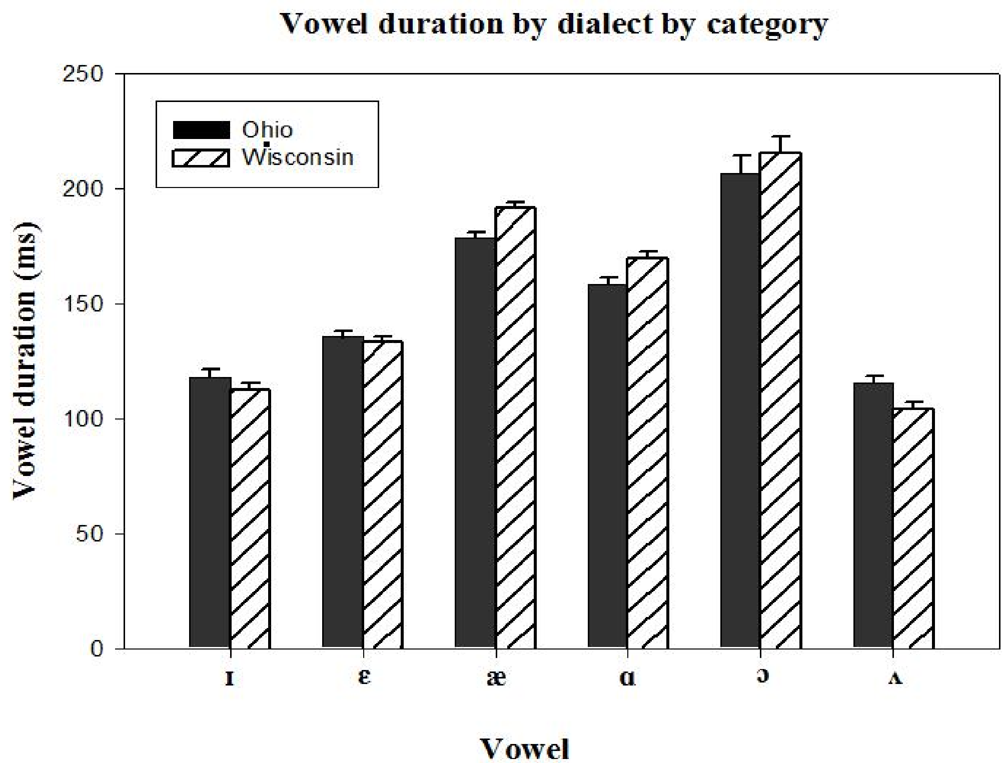

Figure 8. Bar graph of mean vowel durations in each dialect by vowel category.

3.2 Frequency Analysis

The frequency analysis of this study provided a wide range of evidence related to Labov’s beliefs about the acoustic characteristics of vowels in the Midland and North. Specifically, the characteristics of the lax vowels in these two regions highlight several important changes that are presently occurring. In Ohio, we found that as Labov had suggested, /ɑ/ was produced further back than /ʌ/ in every age group, and across both genders. However, in Wisconsin, the male and female grandparent groups both showed /ʌ/ as being more fronted than /ɑ/. The Wisconsin male and female parent groups both showed /ʌ/ moving further back, but not more than /ɑ/. Note that the horizontal and vertical lines in these figures represent the 50% marks of formants 1 and 2, used as a reference point for comparison as well as part of the standard procedure outlined by Labov. As Figures 11 and 12 show, the Wisconsin male and female children groups did not show any significant movement of /ʌ/ further back than /ɑ/. The /ɑ/-/ɔ/ merger was also evident in the younger Ohio speakers.

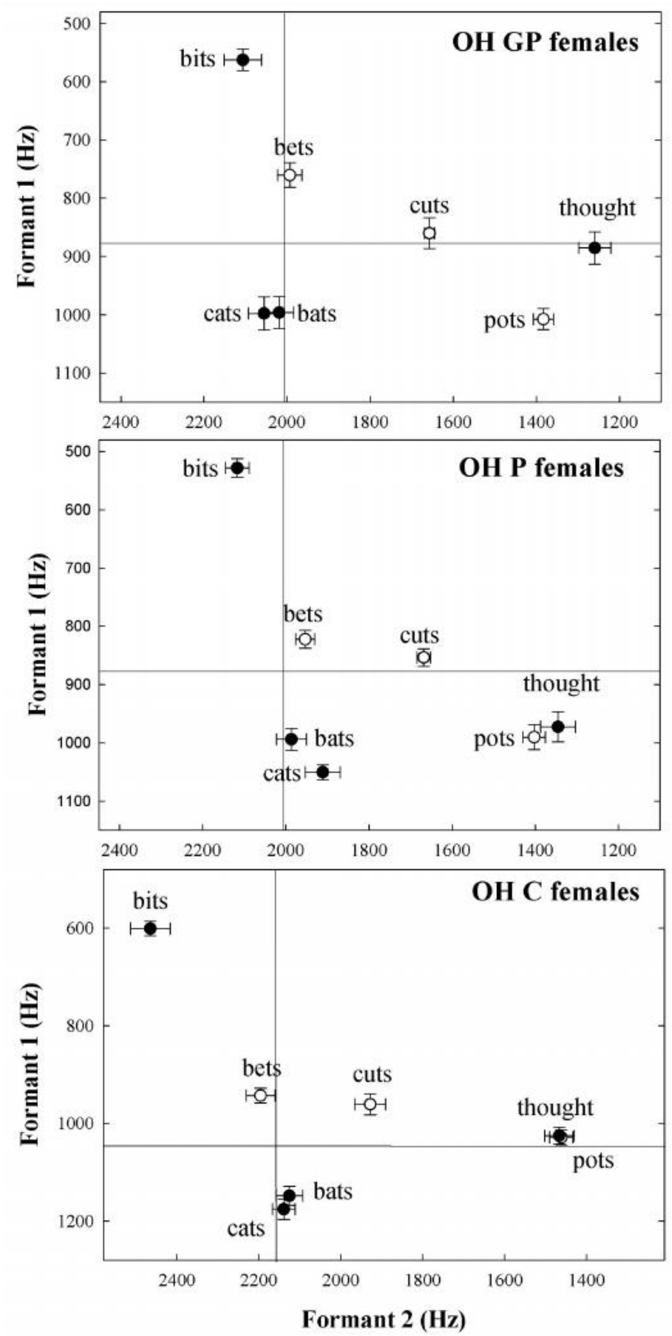

Figure 9. Mean formant estimations for Ohio females.

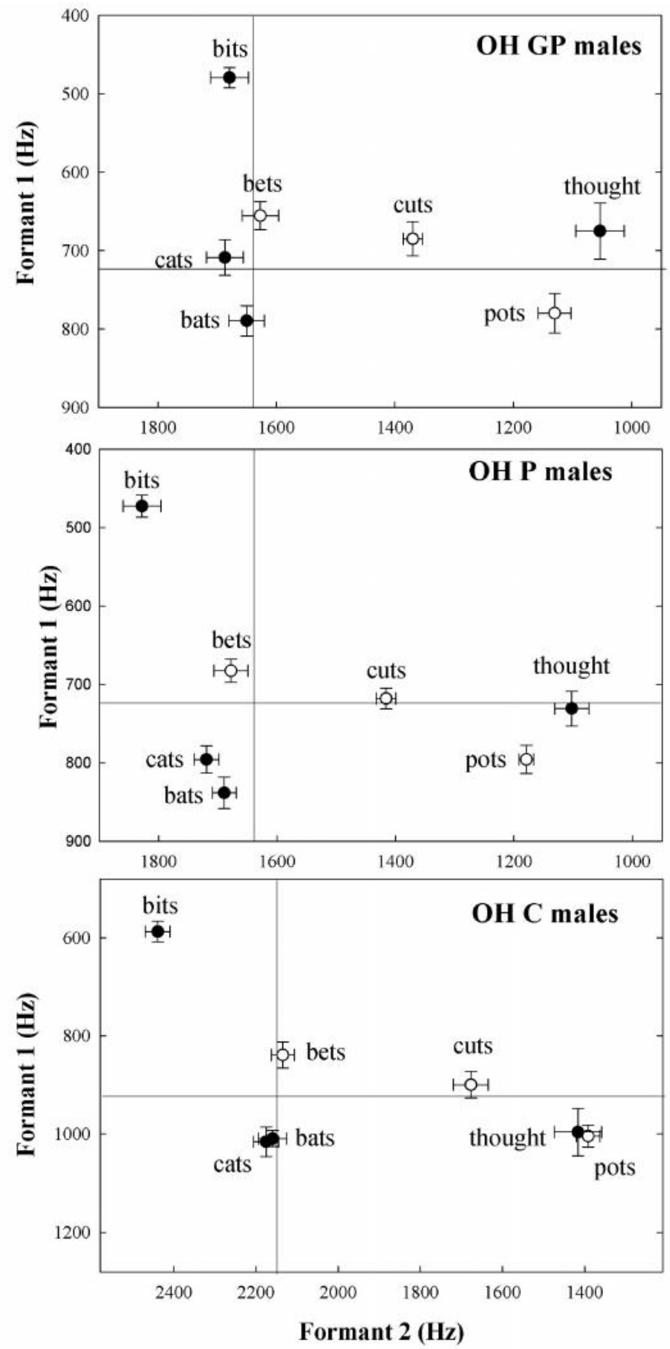

Figure 10. Mean formant estimations for Ohio males.

In Figures 9 and 10, the Ohio grandparent speakers (both male and female) did not show this merger, while the parent speakers showed a closer merging of them, and the children speakers showed almost a complete merging of the two vowels. However, the females in the

Ohio parent and children age groups showed a stronger tendency to merge these two vowels than the Ohio male parent and children groups, confirming the belief that women tend to be the leaders in sound change. In Wisconsin, the /ɑ/-/ɔ/ merger did not appear in any of the male or female age groups.

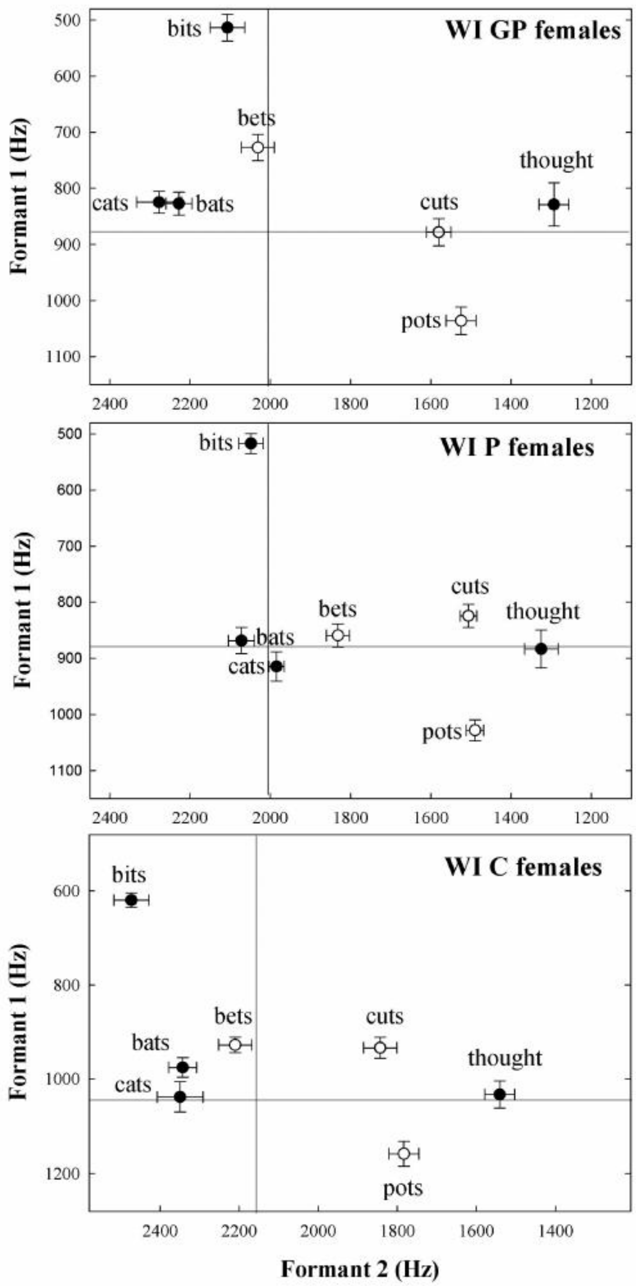

Figure 11. Mean formant estimations for Wisconsin females.

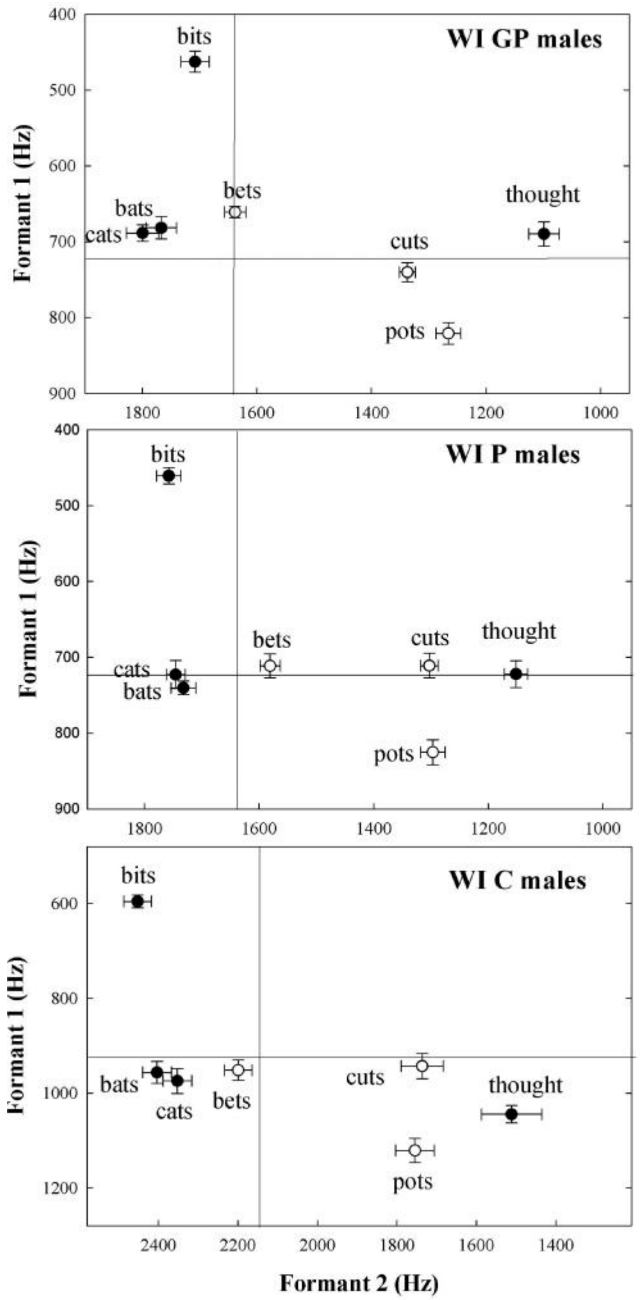

Figure 12. Mean formant estimations for Wisconsin males.

In Wisconsin, the expected characteristics Labov had previously hypothesized were not evident. The lack of shift in the vowel /ʌ/ prevents the consequent stages of the NCS, as outlined by Labov, from occurring. As a result there were no significant shifts in position of the six vowels in each age group or gender.

The analysis of the positions of BATS and CATS in each region showed no significant patterns of change in movement across different age groups or genders, or in relation to any of the other studied vowels.

4. Discussion and Conclusion

Knowledge of dialect characteristics is crucial to understanding potential sound changes or processes which define the region of interest, as well as their relationships with surrounding regional dialects. Studies indicate that analysis of acoustic characteristics of vowels is the most effective way to understand the differences which may exist between regional dialects of North American English. This study focuses on the North and Midland regions in terms of their distinct acoustic characteristics, in addition to the STRUT and LOT vowel relationship which prior research has found to be evident between them.

Wisconsin shows a lack of adherence to the Northern Cities Shift, since the second stage does not appear to be significantly present, and as a result the subsequent vowel rotations do not occur as strongly as expected. Additionally, the STRUT vowel is not produced further back than the LOT vowel. These outcomes lead to a failure to support the claims previously made by Labov, and the predictions made at the beginning of this study.

In Ohio, the predicted characteristics are all present in the data. STRUT is more fronted than LOT, and the aforementioned merger appears to be working in the present data—particularly in the parent and children females—staying consistent with Labov's claims.

The cross-generational change in acoustic characteristics is evident in Ohio's progressive merging of /ɑ/ and /ɔ/ with every younger age group, showing that sound change is an active process in the dialect. Wisconsin does not show any significant shifts in acoustic characteristics through every generation, implying that there is no active sound change in progress in this North region.

While we did not find any evidence confirming Labov's claims about the status of the NCS in southeastern Wisconsin, we can make the conjecture that this is due to the difference in dates at which Labov's data, as well as this study's, was collected. It may be that while Labov found reasonable evidence of the NCS in his older set of speakers, the shift is simply no longer operative in this region.

APPENDIX A

Basic demographic background of the participants (self-reported). Education level is coded as: 1 = elementary, 2 = high school, 3 = two-year college, 4 = four-year college, 5 = graduate degree. ID: C = child, P = parent, GP = grandparent.

Ohio participants

ID	Birth year	Age at testing (years)	Gender	Education	Occupation	Area
OH01_C	1994	12	F	1	Student	Piqua
OH02_C	1996	10	M	1	Student	Columbus
OH03_C	1994	12	F	1	Student	Columbus
OH04_C	1996	10	M	1	Student	Columbus
OH05_C	1995	11	F	1	Student	Columbus
OH06_C	1995	11	F	1	Student	Columbus
OH07_C	1995	11	F	1	Student	Columbus
OH08_C	1996	10	F	1	Student	Columbus
OH09_C	1999	10	M	1	Student	Columbus
OH10_C	1995	12	M	1	Student	Columbus
OH11_C	1997	10	M	1	Student	Columbus
OH12_C	1998	9	F	1	Student	Columbus
OH13_C	1997	10	M	1	Student	Columbus
OH14_C	1999	8	M	1	Student	Worthington
OH15_C	1997	16	M	1	Student	Worthington
OH16_C	1995	12	M	1	Student	Powell
OH17_C	1997	10	M	1	Student	Columbus
OH18_C	1995	12	M	1	Student	Columbus
OH19_C	1995	12	F	1	Student	Worthington
OH20_C	1997	10	M	1	Student	Westerville
OH21_C	1996	11	M	1	Student	Granville
OH22_C	1998	9	F	1	Student	Granville
OH23_C	1995	8	F	1	Student	Upper Arlington
OH24_C	1994	12	F	1	Student	Columbus
OH25_C	1998	9	M	1	Student	Westerville
OH26_C	1996	11	M	1	Student	Grove City
OH27_C	1998	9	F	1	Student	Grove City
OH28_C	1994	12	F	1	Student	Glenford
OH29_C	1998	9	F	1	Student	Columbus
OH30_C	1995	12	F	1	Student	Worthington
OH31_C	1998	9	F	1	Student	Columbus
OH32_C	1998	9	M	1	Student	Columbus
OH33_P	1959	47	F	3	Department office manager	Columbus
OH34_P	1958	48	M	4	Manager, sales marketing	Piqua
OH35_P	1958	48	M	2	Water plant operator	Columbus
OH36_P	1962	44	M	5	Bus driver	Columbus
OH37_P	1964	42	F	5	Homemaker, previous teacher	Lima
OH38_P	1968	39	M	5	Research assistant	Columbus
OH39_P	1969	38	F	5	Curator in research center	Columbus
OH40_P	1968	39	F	4	University staff	Worthington
OH41_P	1968	39	F	3	Preschool teacher	Powell
OH42_P	1970	37	F	5	Substitute teacher	Worthington
OH43_P	1965	42	F	4	Homemaker, previous teacher	Grandville
OH44_P	1965	42	F	5	Speech language pathologist	Columbus

OH45_P	1958	49	F	3	Nurse	Columbus
OH46_P	1969	38	F	5	Teacher	Grove City
OH47_P	1963	44	M	4	Graphic designer	Grandview Heights
OH48_P	1969	38	F	5	Homemaker	Hilliard
OH49_P	1968	39	F	4	Homemaker	Columbus
OH50_P	1960	47	F	5	Occupational therapist	Worthington
OH51_P	1958	49	M	3	Compliance facility director	Columbus
OH52_P	1965	42	F	4	Registered nurse	Columbus
OH53_P	1966	41	M	4	Policeman	Columbus
OH54_P	1967	43	F	4	Registered nurse	Columbus
OH55_P	1973	35	M	5	Teacher	Westerville
OH56_P	1972	35	M	4	IT technician	Hilliard
OH57_P	1968	39	F	4	University staff	Columbus
OH58_P	1964	44	M	5	Student	Ashville
OH59_P	1958	51	M	4	Consultant	Hilliard
OH60_P	1973	36	M	4	Retired, private investor	Columbus
OH61_GP	1938	68	M	5	Retired	Columbus
OH62_GP	1919	87	F	4	Retired homemaker	Columbus
OH63_GP	1935	72	M	5	Retired manager	Worthington
OH64_GP	1939	68	F	2	Retired	Columbus
OH65_GP	1935	72	F	3	Beautician	Columbus
OH66_GP	1931	76	F	3	Retired	Columbus
OH67_GP	1938	69	M	3	School bus driver	Columbus
OH68_GP	1932	75	F	5	Artist	Columbus
OH69_GP	1935	73	M	5	Retired	Columbus
OH70_GP	1934	74	M	2	Retired	Delaware
OH71_GP	1939	69	M	2	Retired	Columbus
OH72_GP	1937	71	F	3	Homemaker	Groveport
OH73_GP	1940	68	M	2	Retired Telephone Co worker	Columbus
OH74_GP	1931	77	F	2	Homemaker	Columbus
OH75_GP	1932	76	F	3	Retired legal secretary	Columbus
OH76_GP	1940	68	M	3	Retired	Columbus
OH77_GP	1934	75	F	4	Retired teacher	Westerville
OH78_GP	1937	71	M	4	Retired fire fighter	Columbus

Wisconsin participants

ID	Birth year	Age at testing (years)	Gender	Education	Occupation	Area
W2088_C	1995	12	F	1	Student	Madison
W2089_C	1998	9	F	1	Student	Madison
W2091_C	1997	10	F	1	Student	Madison
W2093_C	1996	11	F	1	Student	Madison
W2095_C	1997	9	F	1	Student	Madison
W2098_C	1997	9	F	1	Student	Monona
W2099_C	1999	9	F	1	Student	Madison
W2100_C	1999	8	F	1	Student	Madison
W2101_C	1995	12	F	1	Student	Madison
W2102_C	1998	9	F	1	Student	Madison
W2103_C	1998	9	M	1	Student	Madison
W2116_C	1998	9	M	1	Student	Middleton
W2117_C	1999	9	M	1	Student	Middleton
W2118_C	1999	9	M	1	Student	Middleton
W2120_C	1997	10	M	1	Student	Madison
W2121_C	1998	9	M	1	Student	Middleton
W2124_C	1999	8	M	1	Student	Middleton
W2131_C	1997	10	M	1	Student	Madison
W2132_C	1997	10	M	1	Student	Madison
W2133_C	1997	11	M	1	Student	Madison
W2040_P	1968	38	M	5	Researcher	Sun Prairie
W2041_P	1964	42	M	4	Unemployed	Madison
W2042_P	1967	39	F	5	Financial specialist	Madison
W2045_P	1961	45	F	5	Trial attorney	Madison
W2048_P	1960	46	F	4	Health unit coordinator	Madison
W2051_P	1968	38	F	4	Health care manager	Madison
W2052_P	1968	38	F	5	Network engineer	Madison
W2054_P	1961	45	F	4	Small business owner	Oregon
W2055_P	1962	44	M	5	Electrical engineer	Oregon
W2057_P	1957	50	M	5	University professor	Madison
W2058_P	1966	41	F	5	Director of development	Verona
W2062_P	1970	36	F	4	Registered nurse	Madison
W2068_P	1960	46	M	5	Research program manager	Madison
W2076_P	1959	47	F	3	Correction officer	Fond du lac
W2079_P	1958	49	F	5	Attorney	Madison
W2081_P	1966	40	M	5	Teacher (Middle school)	Madison
W2092_P	1959	48	M	5	Student	Madison
W2129_P	1968	40	M	3	Clerk at Walgreens	Sun Prairie
W2049_GP	1928	79	M	3	Retired	Madison
W2061_GP	1936	70	M	5	Retired physician	Madison
W2070_GP	1936	70	M	4	Retired civil engineer	Madison
W2071_GP	1931	75	F	2	Retired	Monona
W2072_GP	1931	75	M	5	Retired	Madison
W2073_GP	1932	74	F	4	Retired	Madison
W2080_GP	1931	76	M	5	Professor	Madison
W2083_GP	1924	83	F	2	Florist, retired teacher	Madison
W2086_GP	1920	86	F	2	Retired registered nurse	Madison
W2087_GP	1924	83	F	4	Retired registered nurse	Monona
W2104_GP	1932	75	M	5	Retired –VP purchasing	Madison
W2128_GP	1935	72	F	5	Registered nurse	Madison

W2130_GP	1939	68	M	3	Retired farmer	Sun Prairie
W2134_GP	1918	90	F	1	Retired	De Forest
W2135_GP	1922	85	M	5	Retired	Madison
W2142_GP	1935	72	F	2	Retired	Menominee Falls

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